Use of a Wellbeing Framework for Establishing Building Sustainability Performance Requirements in Building Regulations

L Bellamy[1], P Pancholy[1], A Bolton[2] and M Pahlow[1]

[1] Department of Civil and Natural Resources Engineering, University of Canterbury, Christchurch, New Zealand
[2] Institute of Environmental Science and Research, Christchurch, New Zealand

E-mail: larry.bellamy@canterbury.ac.nz

Received xxxxxx
Accepted for publication xxxxxx
Published xxxxxx

Abstract

Improving the sustainability of New Zealand's housing stock is a significant challenge. Economic, indoor climate and energy use data indicates the affordability, healthiness and environmental impacts of new and existing houses in New Zealand are relatively poor compared with other OECD countries. Poor performance is largely due to the building energy and environmental performance requirements prescribed by regulations, which are low in New Zealand compared with other jurisdictions. Building performance requirements will need to be raised in order to improve the sustainability of housing.
A wellbeing approach to determining public benefits from raising building performance requirements in regulations is outlined in this paper. This approach draws on the Living Standards Framework (LSF) developed by The New Zealand Treasury. This framework links 12 domains of wellbeing to each other and to 4 capital stocks, including housing, that underpin future wellbeing. The LSF is used to assess the impacts of raising building performance requirements on community wellbeing. Results indicate better knowledge of the relationships between the domains of wellbeing and the underpinning capital stocks is needed to improve the identification and analysis of preferred regulatory settings.

Keywords: housing sustainability, intergenerational wellbeing, Living Standards Framework, building performance regulations, cost benefit analysis, decarbonisation

1. Introduction

Over the last decade there have been a number of initiatives to improve the sustainability and resilience of New Zealand's building stock. Identifying and strengthening earthquake-prone buildings was a priority after the devastating 2010-11 Canterbury earthquakes [1]. More recently, attention has also focussed on improving housing affordability and indoor environmental quality – inter-related problems that are having a negative impact on the wellbeing of New Zealanders [2].

Reducing housing greenhouse gas [GHG] emissions may soon be added to these housing sustainability challenges, given the country has committed to ambitious emission reduction targets. The Climate Change Response (Zero Carbon) Amendment Act 2019 [3] aims to reduce all GHG emissions, except biological methane, to 'net zero' by 2050 (hence aiming to limit the global temperature increase to 1.5°C above pre-industrial levels). This Act sets the framework for New Zealand to transition to a low emissions and climate resilient economy.

The Building Act 2004 [4] is the primary instrument for regulating the indoor environmental quality of new housing in New Zealand. Indoor environmental quality appears to be poor in New Zealand housing compared with other OECD countries (Table 1), which raises the question whether housing thermal design standards should be raised in regulations under the Act. It could be argued that higher insulation, shading, ventilation, heating and cooling standards are needed anyway, given modern New Zealand homes are prone to mould, dampness [5], low indoor temperatures (due to energy poverty [6]) and overheating [7].

Housing greenhouse gas emissions are currently not regulated in New Zealand but new regulations to decarbonise housing could be introduced under the Act, since a high-level purpose of the Act is to set building performance standards to promote sustainable development.

Support for new or stronger regulation to improve the sustainability of New Zealand's housing depends, amongst other things, on the economic analysis in a Regulatory Impact Assessment (RIA), prepared by Government officials when regulatory change is proposed. A new approach for including environmental, social and economic impacts into economic analyses has recently been introduced into the cost benefit analysis tool used when preparing RIAs [8]. Including these impacts into economic analyses is not new. What is new is the use of the Living Standards Framework (LSF) [9], being developed by the New Zealand Treasury, to systematically consider the cascading impacts of policies, such as regulatory changes, on intergenerational wellbeing.

Table 1: Inter-jurisdictional comparison of housing sustainability.

Housing Sustainability Indicator	Country/State				
	NZ	Australia	UK	USA	Sweden
Homes with mould [%]	49 [10]	35 [11]	30 [12]	31 [13]	6 [12]
Mean winter indoor air temperature [°C]	14.7-16.5[14]	16.6-21.2[15]	18.9 [16]	19.1-21.5[17]	20-23 [18]
Annual operational carbon emissions [kg(CO_{2e}) per capita]	310 [19]	530 [20]	1290 [21]	1220-1260 [22]	63 [23]

1.1 Living Standards Framework (LSF) and UN Sustainable Development Goals (SDG)

The primary purpose of the LSF is to track changes to wellbeing outcomes over time and improve public policy-making, with the ultimate goal of lifting living standards and improving intergenerational wellbeing [9].

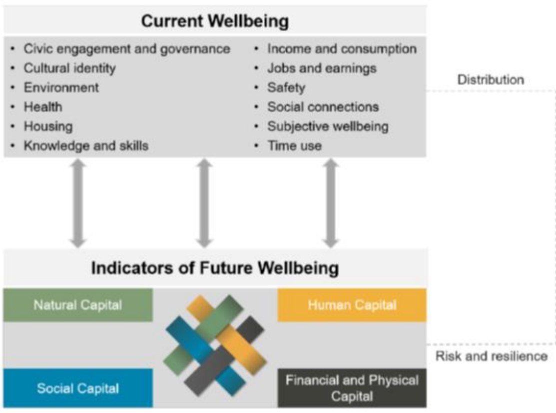

Figure 1: The Living Standards Framework. Adapted from [9].

The elements of the LSF, shown in Figure 1, are 12 domains of current wellbeing, and four types of capital that together generate current and future wellbeing. The third element of the LSF is the risk and resilience associated with the 4 capitals.

Table 2 maps the LSF to the UN Sustainable Development Goals (SDG). All SDGs are covered by an LSF wellbeing domain or capital, except for Goals 5 and 10, Gender Equality and Reduced Inequalities. However, the LSF covers these goals by assessing how wellbeing is distributed across different groups in society, for each wellbeing domain.

Note, only primary relationships between LSF wellbeing domains and capitals and SDGs are shown in Table 2.

Table 2: Mapping Living Standards Framework (LSF) to UN Sustainable Development Goals (SDG). Adapted from [24].

LSF Wellbeing Domain	**SDG**
Civic Engagement & Governance	16. Peace & Strong Institutions
Cultural Identity	None
Environment	6. Clean Water & Sanitation 11. Sustainable Cities & Communities 12. Responsible Consumption & Production 13. Climate Action 14. Life Below Water
Health	3. Good Health & Well-being
Housing	11. Sustainable Cities & Communities
Knowledge & Skills	4. Quality Education
Income & Consumption	1. No Poverty 2. Zero Hunger
Jobs & Earnings	8. Decent Work & Economic Growth
Safety	16. Peace, Justice & Strong Institutions
Subjective Wellbeing	None
Social Connectedness	None
Time Use	None
LSF Capitals	SDG
Natural Capital	13. Climate Action 14. Life Below Water 15. Life on Land
Social Capital	16. Peace, Justice & Strong Institutions 17. Partnerships for the Goals
Human Capital	3. Good Health & Wellbeing 4. Quality Education
Financial & Physical Capital	7. Affordable & Clean Energy 9. Industry Innovation & Infrastructure 12. Responsible Consumption & Production

1.2 Modelling Changes in Wellbeing Using a Stock and Flows Technique

A wellbeing model, being developed as part of the LSF initiative, uses a 'stocks and flows' approach to analysing wellbeing [25]. The capital stocks represent the wealth of the country that is drawn on to generate beneficial flows of wellbeing (e.g. employment, leisure, freedom, environmental services). In using certain stocks to generate flows, other forms of capital and flows may be affected. The LSF model formulates these interactions in an attempt to quantify the impacts of public policies and investments on wellbeing.

The nature of these interactions is not yet well understood, notwithstanding the significant body of econometric research on the relationships between certain aspects of wellbeing, such as education and social connection, health and income, and health and life satisfaction. While the LSF model is currently of limited use for quantifying impacts, it is useful for identifying which aspects of wellbeing are impacted by public policies and investments, and the likely scale of these impacts. It is also useful for integrating new and existing knowledge of wellbeing to provide a clearer picture of the cascading impacts of public policies and investments.

1.3 Objectives of the Paper

The objectives of this paper are:

- Identify the cascading impacts on wellbeing from improving housing sustainability by reducing housing greenhouse gas emissions and improving indoor environmental quality, i.e. investing in low-energy low-carbon housing (LELCH).
- Undertake a case study to investigate how a wellbeing approach affects the cost benefit analysis of investing in improved housing sustainability.

Low-energy housing is defined here as housing that all New Zealand households could affordably heat to maintain healthy indoor environmental conditions, i.e. nearly zero energy is required for space heating. Low-carbon housing is defined as low energy housing that is supplied with renewable energy.

2. Applying the Living Standards Framework to Improving Housing Sustainability

2.1 Modelling Impacts of Investing in Low-Energy Low-Carbon Housing (LELCH)

Following the approach used by Karacaoglu *et al*. [26], the LSF model was used to identify the cascading impacts on wellbeing due to Government policies that drive investment in LELCH. These impacts are shown in Figure 2. Impacts may be considered as 1st, 2nd or 3rd order. 1st order impacts refer to the initial consequence of the action, second order impacts refer to the consequence of the first order impact, and so on.

Figure 2 shows the 1st order impacts from investment in LELCH are increased **Government spending (A)** and four impacts on building users: increased **Cultural wellbeing (B)**; decreased **Energy consumption (C)**; increased **Health level (D)**; and increased **Jobs (Employability) (E)**. The 1st order impacts cascade to sixteen 2nd order and thirty-eight 3rd order impacts. Of the five 1st order impacts, Jobs (Employability) has the greatest number of 2nd and 3rd order impacts and Health level (highlighted in green in Figure 2) is the most pervasive impact, inasmuch it is the most common of the combined 2nd and 3rd order impacts.

While reduction in Energy consumption (C) and increase in Health level (D) are obvious positive outcomes of such an investment decision, impacts on other aspects of wellbeing such as Government spending (A), Cultural wellbeing (B) and Jobs (E) were also revealed in the model. The next section explores these impacts in more detail, as well as a number of second and third order impacts, with a particular focus on health, energy and environmental impact.

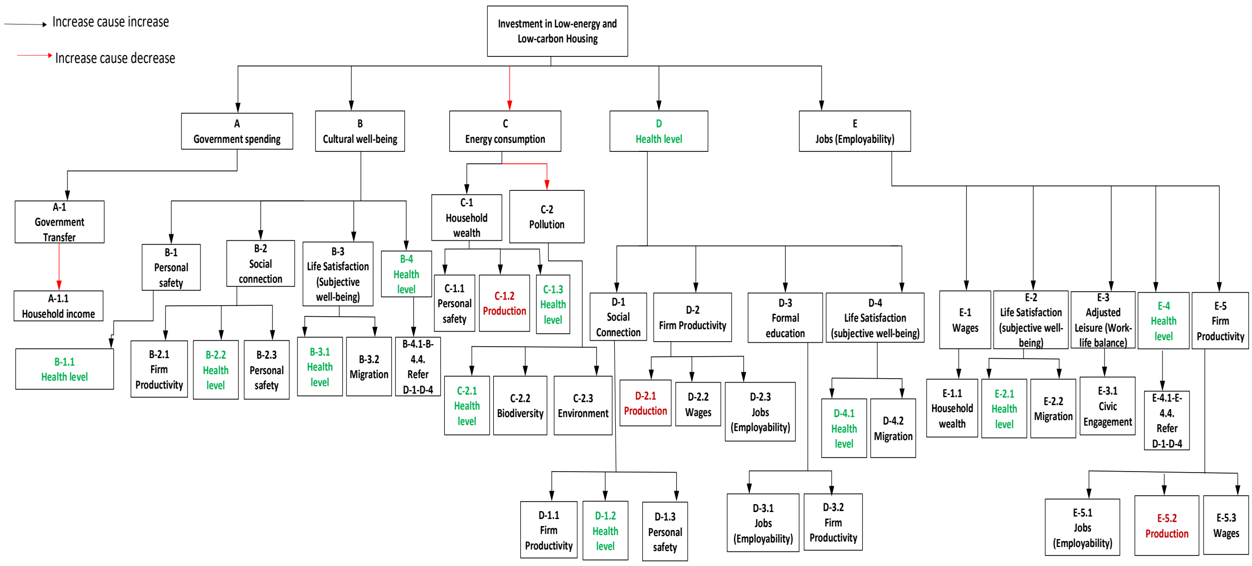

Figure 2: Impacts on wellbeing of investment in low-energy low-carbon housing.

2.2 Major and Minor Impacts of Investment in Low-Energy and Low-Carbon Housing

Policies that drive investment in LELCH would require an increase in **Government spending (A)** on public housing, which reduces Government transfers to households and household income.

Cultural wellbeing (B) is related to identity and can be described as a sense of belonging, value and cultural diversity. As with many other indigenous people worldwide, colonization has led to dispossession of land and destabilization of cultural foundations [27]. These systems are preserved through colonial systems and structures that maintain an inequitable distribution of the factors of health. Such effects may cause significant morbidity and mortality of indigenous people. Valuing cultural practices, and establishing mechanisms for indigenous people's participation in decision making about health and housing services may contribute towards their sense of belonging, cultural wellbeing and equal rights in society. This may improve social connections, life satisfaction and feeling of personal safety. The obvious outcome of all above improvements could be improvement in mental health.

In terms of **Energy consumption (C)**, up to a third of New Zealand households reported difficulty paying power bills and spending a large portion of their income paying for power [6]. Fuel poverty is therefore an issue for many. In a study of people with chronic respiratory illness, Viggers *et al.* [28], found that many reported feeling frequently cold in their houses and had to economise on heating. Renters were more likely to report this issue. Similar findings in a Southern District Health Board [29] study in Central Otago found housing issues associated with affordability and availability that restricted heating budgets. This is compounded by lower than average household net-adjusted disposable income per capita in New Zealand compared to the rest of the OECD [30].

The impacts described above are demonstrated in the LSF model as second order impacts. Here, a decrease in **Energy consumption (C)** cascades into an increase in household wealth (C-1) and decrease in pollution (C-2). Increased household wealth cascades into increased personal safety (C-1.1), production (C-1.2) and health level (C-1.3). The latter impact is particularly notable if the user has a limited budget for energy costs. Reduced pollution (C-2) improves biodiversity and environmental outcomes (e.g. better air quality and environment), thus reinforcing health and wellbeing. However, the assumption here is that fossil fuel use is reduced or replaced and not used as an energy source at both the operational and building cycle. Decreased levels of pollution (C-2) also cascade into increased health level (C-2.1) as well as increased biodiversity (C-2.2) and environment (C-2.3).

In terms of **Health level (D)**, vulnerable populations (e.g. children and older people) are more likely to benefit from LELCH due to improved indoor environmental quality [31]. Presumably, warmer, drier homes would reduce the known health impacts associated with poor housing [28, 32], thus increasing **Health level (D)**. Increased health level leads to a number of second order impacts including increased social connection (D-1), firm productivity (D-2), formal education (D-3) and life satisfaction (D-4). It is assumed that these impacts result in opportunities to enage in these areas, and in doing so lead to further cascading benefits. For example, for adults, increased health level may lead to more opportunities for education and skills (D-3), important requisites for employment (D-3.1).

The design and construction of LELCH will require different skill sets, materials and processes than conventional houses, and will therefore impact **Jobs (E)** and the labour market [31]. An increase in higher-skilled jobs is associated with a lift in firm productivity (E-5), which increases production (E-5.2) and lifts wages (E-5.3). Higher wages (E-1) and more satisfying work (E-2) lifts household wealth (E-1.1) and increases health (E-2.1). Improvement in life satisfaction (E-2) can also increase migration (E-2.2).

3. Case Study: Cost Benefit Analysis of Raising Insulation Standards of Christchurch Houses

High levels of insulation are typically a key element of any strategy to achieve LELCH. So raising insulation standards of new houses is considered here as a case study to explore how the LSF may be applied to cost benefit analyses of public investments in LELCH. Construction R-values for current and higher (hypothetical values) insulation standards are shown in Table 3.

Table 3: Current and proposed high (hypothetical case) insulation standards for Christchurch (43.5ºS) housing.

	Minimum Construction R-value [m^{2}K/W]	
Building Element	Current insulation standards	Higher insulation Standards
Roof	3.3	6.6
Wall	2.0	4.0
Floor	1.3	2.6
Windows and glazing	0.26	0.52

3.1 Economic case based on heating energy savings

A simple approach to evaluating the economics of LELCH is to only consider reductions in heating energy costs. In practice, cost reductions are estimated by simulating the thermal performance of a set of ‘typical’ house designs at a number of locations, in an attempt to represent the housing stock. Here, the Sefaira building simulation software was used to analyse the effects of higher insulation on the thermal performance of one house design at one location – a 150 m^2 single-storey model house (Figure 3) located at Christchurch (43.5ºS).

The model house is constructed with timber-frame walls and roof, and a concrete slab-on-ground floor. It is heated with electric resistance heaters, cooled by natural ventilation and does not have a mechanical cooling system.

Figure 3: Floor plan of model house.

A minimum indoor temperature of 20°C was continuously maintained in the model house during daytime (6am-10pm) and 16°C during night-time (10pm-6am), for householders with an unlimited heating budget. For households with a limited heating budget, the simulated heating strategy was to heat living rooms to 20°C during the evening and for as long as possible during the rest of the daytime if the budget allowed, and avoid living room temperatures below 16°C. Heating the bedrooms was treated as the lowest priority of these households.

Table 4 shows the higher insulation standards reduce heating energy use by up to 30 kWh/m^2 (floor) per annum. This represents a reduction in annual heating energy costs of NZ$7.50/m^2 (floor) if the electricity price is NZ$0.25/kWh. The Present Value of these cost reductions over 50 years, using a 6% discount rate, is $118/m^2 (floor), which does not justify these higher insulation standards.

Most houses are not continuously heated to full comfort, and would not produce the cost reduction indicated above. Households with a limited heating budget may not produce any reduction in heating energy costs, as indicated by the energy use data in Table 4. This weakens the economic case of higher insulation standards, if co-benefits such as improved health are not included in the economic analysis.

Table 4: Model house heating energy use and incidence of low indoor air temperatures (<16°C) over the heating season (Apr-Oct).

Annual Heating Energy Budget	**Heating Energy Use [kWh/m2(floor)]**		**Incidence of Low Indoor Air Temperatures (< 16°C) in an Occupied Zone [hours]**[2]	
	Current insulation standards	Higher insulation standards	Current insulation standards	Higher insulation standards
Unlimited	52.4	22.2	0	0
$500	13.3[1]	13.3[1]	1052	0
$300	8.0[1]	8.0[1]	1112	0

1. Based on 100% efficient electrical heating and a unit electricity price equal to NZ$0.25/kWh.
2. Combines the incidence of low air temperatures in the living rooms during the daytime (6am-10pm) and bedrooms during the night-time (10pm-6am).

There could be other higher insulation standards, with R-values differing from those in Table 3, that are economically justified based only on heating energy cost reductions. It is not the goal of this paper to determine what these R-values may be. Of interest here is how other impacts may be included in cost benefit analyses.

3.2 Economic case based on energy savings and other benefits

Including other economic benefits, such as reduced health costs and reduced damage from CO_2 emissions, into cost-benefit analyses can significantly strengthen the economics of investment in improved housing quality [32]. With reference to Figure 2, total economic benefits B ($/year) from investment in LELCH can be expressed as:

$$B = W + I + H + S + P$$

where

$W = f(\Delta C)$ is the reduction in heating and cooling costs (energy and equipment capital costs), which is a function of the reduction in energy consumption (ΔC), which in turn depends on housing (and urban) design, climate and behaviour of housing occupants.

$I = f(\Delta C)$ is the reduction in global damage due to reduced carbon emissions from the national housing stock, which is a function of the reduction in energy consumption.

Table 5: Reverse analysis of benefits of higher insulation standards.

Benefit	Present Value of Benefit [\$/m2(floor)][1]	Comment
Reduced heating and cooling costs	59.0	Based on 50% of households living in fully heated homes that reduce annual heating energy costs by \$7.50/m2.
Reduced damage from carbon emissions	3.0	Based on a social cost of carbon of \$NZ\$100/tonne and a carbon loading of 130 grams CO2e per kWh for electricity.
Reduced health costs	10.5	Based on eliminating doctor and hospital costs due to cold/damp that averages \$200/year for 50% of households living in cold homes. Average house size is 150 m2.
Reduced crime costs	-	Ignored for this analysis.
Increased production	127.5	Required increase in national production to make this proposal worthwhile based on other assumed benefits
Total	200	Threshold Present Value for proposal to be worthwhile.

1. Based on 50 years and 6% discount rate.

$H = f(\Delta B, \Delta C, \Delta D, \Delta E)$ is the reduction in national health costs due to improved indoor environmental conditions, increased sense of wellbeing and social connections due to better health, increased pride of home and place, and increased household wealth due to upskilling the workforce to deliver LELCH. H is a function of the increase in cultural wellbeing (ΔB), reduction in energy consumption (ΔC), increase in health due to reduced exposure to unhealthy indoor conditions (ΔD) and improved work skills and employability (ΔE). H depends on housing (and urban) design and skills development of the workforce.

$S = f(\Delta B, \Delta E)$ is the reduction in the national costs of crime due to increased social connections and increased household wealth. S also depends on housing (and urban) design and skills development of the workforce.

$P = f(\Delta B, \Delta D, \Delta E)$ is the increase in firm productivity and national production due to the improved health, increased social connections, increased sense of wellbeing and higher skills of the workforce. This benefit also depends on housing (and urban) design and skills development of the workforce.

Identifying functional relationships for the last four economic benefits listed above is an ongoing challenge. In the meantime, these benefits may be included in cost benefit analyses using a reverse analysis, which takes the approach 'what would it take to make the proposal be worthwhile' [8].

The outline of a simple reverse analysis of the hypothetical case of higher insulation standards (Table 3) is shown in Table 5. This is based on the (untested) assumption that the higher insulation standards would increase construction costs by approximately \$200/m^2(floor), and that 50% of new housing (by area) has an unlimited heating energy budget while the other 50% has a budget of NZ\$300/year. Clearly there is a range of heating behaviours that should be considered when estimating the Present Value of reduced heating energy and health costs.

The purpose of the reverse analysis in Table 5 is to outline the use of LSF in cost benefit analyses, not to determine whether or not higher insulation standards are worthwhile. It highlights the importance of identifying and considering all benefits when analysing the economics of LELCH, not just reductions in heating energy costs. It appears from this simple analysis that the impact of housing design on production will be important when assessing the economics of LELCH.

Benefits that have not been considered in Table 5, which are expected to be important when assessing the economics of LELCH, include reduction in the capital costs associated with heating and cooling systems, and improved health from reduced overheating.

4. Conclusions

The New Zealand Treasury's Living Standards Framework (LSF) was applied to low-energy low-carbon housing LELCH. A wellbeing model developed as part of the LSF initiative was used to identify the cascading impacts of policies that drive investment in this type of construction. The economic case for investment in LELCH depends on five major benefits. One of these economic benefits – reduced heating and cooling costs – is captured by individual households. The four other economic benefits – reduced damage from carbon emissions, reduced health costs, reduced crime costs and increased production – flow to the wider public. All should be considered in cost benefit analyses of LELCH policies.

There is a growing body of evidence of the effects of housing on health, wellbeing and social connections. However, we are some way off being able to model the economic impact of housing design on health, crime, productivity and production, let alone the intrinsic value society places on health, social connections, personal safety and other non-economic aspects of wellbeing. These models are needed to support the policy and investment decisions that will be taken to reduce carbon emissions.

Acknowledgements

We would like to thank Zach Frame, Lucy Washer, David Van Drimmelen and Zain Kader for the background research they undertook on sustainable housing while students at the University of Canterbury.

References

[1] New Zealand Parliament 2016 Building (Earthquake-Prone Buildings) Amendment Act 2016 Wellington, New Zealand

[2] Johnson A, Howden-Chapman P and Eaqub S 2018 A Stocktake of New Zealand's Housing Ministry of Business, Innovation & Employment

[3] New Zealand Parliament Climate Chage Response (Zero Carbon) Amendment Act 2019 Wellington, New Zealand

[4] Building Act 2004 New Zealand Legislation Department of Building and Housing, New Zealand Government, Wellington, New Zealand

[5] Cox-Smith I 2016 New Homes Dripping: BRANZ, NZ

[6] Howden-Chapman P, Viggers H, Chapman R, O'Sullivan K, Barnard L T and Lloyd B 2012 Tackling Cold Housing and Fuel Poverty in New Zealand: A Review of Policies, Research, and Health Impacts Energy Policy 49 134-42

[7] Birchmore R, Davies K, Etherington P, Tait R and Pivac A 2017 Overheating in Auckland Homes: Testing and Interventions in Full-Scale and Simulated Houses Building Research & Information 45 157-75

[8] New Zealand Treasury 2017 CBAx Tool User Guidance: Guide for Departments and Agencies using Treasury's CBAx Tool for Cost Benefit Analysis: Wellington, New Zealand Government

[9] Treasury 2018 Living Standard Framwork: Background and Future work New Zealand Treasury

[10] White V, Jones M, Cowan V and Chun S 2017 BRANZ 2015 House Condition Survey: Comparison of House Condition by Tenure Porrirua, New Zealand, BRANZ

[11] Meszaros D, Burgess J, Walters E H, Johns D, Markos J, Giles G, Hopper J, Abramson M, Dharmage S C and Matheson M 2014 Domestic Airborne Pollutants and Asthma and Respiratory Symptoms in Middle Age Respirology 19 411-8

[12] Norback D, Zock J P, Plana E, Heinrich J, Tischer C, Jacobsen Bertelsen R, Sunyer J, Kunzli N, Villani S and Olivieri M 2017 Building Dampness and Mould?? in European Homes in Relation to Climate, Building Characteristics and Socio-Economic Status: The European Community Respiratory Health Survey ECRHS II Indoor Air 27 921-32

[13] Antova T, Pattenden S, Brunekreef B, Heinrich J, Rudnai P, Forastiere F, Luttmann-Gibson H, Grize L, Katsnelson B and Moshammer H 2008 Exposure to Indoor Mould and Children's Respiratory Health in the PATY Study Journal of Epidemiology & Community Health 62 708-14

[14] Isaacs N, Saville-Smith K, Camilleri M and Burrough L 2010 Energy in New Zealand Houses: Comfort, Physics and Consumption Building Research & Information 38 470-80

[15] Asumadu-Sakyi A, Thai P, Barnett A and Morawska L 2016 Pilot Study on Relationship between Indoor and Outdoor Temperatures in Brisbane Households In: Paper presented at the 7th International

Conference on Energy and Environment of Residential Buildings, Brisbane: Queensland University of Technology Australia
[16] Huebner G M, Hamilton I, Chalabi Z, Shipworth D and Oreszczyn T 2018 Comparison of Indoor Temperatures of Homes with Recommended Temperatures and Effects of Disability and Age: An Observational, Cross-Sectional Study BMJ open 8
[17] Booten C, Robertson J, Christensen D, Heaney M, Brown D, Norton P and Smith C 2017 Residential Indoor Temperature Study
[18] Blom N 2014 Folkhälsomyndighetens Allmänna Råd Om Temperatur Inomhus (The public health authority's general advice about indoor temperature) Folkhälsomyndighetens
[19] IEA 2017 Energy Policies of IEA Countries: New Zealand 2017 Review Paris, France, International Energy Association
[20] IEA 2018 Energy Policies of IEA Countries: Australia 2018 Review Paris, France, International Energy Association
[21] IEA 2012 Energy Policies of IEA Countries: UK 2012 Review Paris, France, International Energy Association
[22] IEA 2014 Energy Policies of IEA Countries: USA 2014 Review Paris, France, International Energy Association
[23] IEA 2013 Energy Policies of IEA Countries: Sweden 2013 Review Paris, France, International Energy Association
[24] Ormsby J 2018 The Relationship between the Living Standards Framework and the Sustainable Development Goals
[25] King A 2018 Living Standards Analysis Model: The First Prototype
[26] Karacaoglu G, Krawczyk J B and King A 2019 Intergenerational Wellbeing and Public Policy: An Intgrated Environmental, Social, and Economic Framework Springer Singapore
[27] Jones R, Bennett H, Keating G and Blaiklock A 2014 Climate Change and the Right to Health for Māori in Aotearoa/New Zealand Health and Human Rights Journal 16 54-68
[28] Viggers H, Howden-Chapman P, Ingham T, Chapman R, Pene G, Davies C, Currie A, Pierse N, Wilson H and Zhang J 2013 Warm Homes for Older People: Aims and Methods of a Randomised Community-Based Trial for People with COPD BMC public health 13 176
[29] Southern District Health Board 2019 Central Otago Housing: The Human Story 1-34
[30] OECD 2017 Better Life Index http://www.oecdbetterlifeindex.org/#/11111111111
[31] Gouldson A, Sudmant A, Khreis H and Papargyropoulou E 2018 The Economic and Social Benefits of Low-Carbon Cities: A Systematic Review of the Evidence Coalition for Urban Transitions
[32] Braubach M, Jacobs D E and Ormandy D 2011 Environmental Burden of Disease Associated with Inadequate Housing: A Method Guide to the Quantification of Health Effects of Selected Housing Risks in the WHO European Region World Health Organization